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RESEARCH REPORT
on

THE THERMAL RADIATION CHARACTERISTICS OF AIRSHIP FABRICS

Lab. Project 5046-3, Part 106, Final Report
NS 081-001

Technical Objective AW-7
AFSWP 1012

10 October 1956

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SUMMARY

Three airship fabrics submitted by the Naval Air Station, Lakehurst, New Jersey, were exposed to intense thermal radiation in the laboratory, simulating field pulses corresponding to weapon yields of approximately 40, 100 and 1500 KT. The critical radiant exposures of the material as measured for these energy releases were correlated with weapon yield.

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ADMINISTRATIVE INFORMATION

1. This investigation has been conducted at the Naval Material Laboratory as part of the program originally proposed by Commander, New York Naval Shipyard Confidential letter S99/L5, Serial 960-92 of 15 March 1950 and formally approved by Bureau of Ships Speedletter S99-(0)(348), Serial 348-75, of 6 April 1950. The Naval Material Laboratory's Thermal Radiation Studies are under the sponsorship of the Armed Forces Special Weapons Project. This particular problem was authorized in a conference of AFSWP and Naval Material Laboratory personnel at Washington, D. C. on 31 May 1956.

ACKNOWLEDGEMENT

2. This investigation was prosecuted by personnel of the Optics Section, Thermal Radiation Materials Unit, under the supervision of T. I. Monahan.

INTRODUCTION

3. As part of its general program on the effects of thermal radiation of atomic explosions, the Naval Material Laboratory is evaluating the characteristics, under exposure to intense thermal radiation, of the various materials of interest to the several agencies of the Department of Defense. As data become available, these findings are published. Reported below are the critical radiant exposures of three airship fabrics, submitted by the Naval Air Station, Lakehurst, New Jersey. A relationship correlating the critical radiant exposure for initial damage and for destruction of the material, with weapon yield has been determined.

EXPOSURE METHODS AND EQUIPMENT

4. The materials consisted of three rubberized fabrics, of which two had one surface aluminized (GAC nos. 113 A 100 and 113 A 70). The third material (GAC No. 128 A 170) was black on both surfaces. Specimens for exposure were cut into strips, 70 mm x 15 mm, with the longest dimension along the warp, as indicated on the specimen sheets by the Naval Air Station, Lakehurst, N. J. The specimens were mounted for exposure by perforating at one end and hanging from a pin behind a 10 mm wide slit cut into a 0.02 inch-thick aluminum sheet. The shield served to protect the edges of the specimen from exposure and, thereby, minimize edge effects. The specimens were held flat against the slit by tape at the bottom of the strip, so that no appreciable tension was applied to the fabric.

5. The source of radiation employed in these experiments was a standard Navy 16 mm carbon arc lamp operating at 78 volts and 150 amps. The lamp is mounted at the focus of a 36-inch mirror which collimates the radiation. A second similar mirror, placed coaxially with the first, condenses the radiation at its focus, where the specimens were exposed.

6. The bomb-simulating thermal pulse is produced by a venetian blind shutter placed in the collimated beam between the mirrors. The shutter is driven by an appropriately designed cam geared to a variable speed motor. The gear system and motor make possible a wide range of pulse times.

7. The maximum irradiance in the exposure plane with this lamp, mirror and shutter arrangement is 63 cal/cm^2 sec. over a circular area 5 mm in diameter, which falls off to 88 percent of maximum over a diameter of 9 mm. Attenuating screens placed in the collimated beam reduce the irradiance to desired levels.

8. The exposure time is controlled by a solenoid-driven knife-blade shutter which is triggered for opening and closing by the cam. The total exposure time is measured by an electric clock connected with the timing cam.

9. The exposures, for which results are given in the table, were made with a pulse whose characteristic is given by the expression:

$$Q = 2.06\ H_{max}\ t_{max}$$

where Q is the total radiant exposure for the equivalent field pulse and t_{max} is the time for the irradiance to reach a maximum (H_{max}). The total time of the pulse is approximately nine times t_{max}. The values of t_{max} used in these exposures correspond to simulated weapons of 39, 113 and 1550 KT. The values of Q given in this report are the radiant exposures for the corresponding field pulse.

10. The spectral reflectances of the three materials were measured in the spectral region, 0.39 to 2.7 microns. The radiant absorptances of the materials for carbon-arc radiation were computed from these data and the spectral energy distribution of the carbon-arc source of intense thermal radiation.

RESULTS

11. Three stages of degradation of the material were observable on the two aluminum surfaced fabrics. These consisted of a visible surface change, destruction of the surface, and destruction of the fabric. The black ballonett material exhibited two stages of destruction; first, a delamination or blistering, and, second, destruction of the fabric.

12. The initial phase of destruction on N-113 A 100, an aluminum surfaced basketweave occurred in the range from 26 to 44 cal/cm^2 for the three weapon sizes. The heavier N 113 A 70 showed initial effects in the range from 13 to 27 cal/cm^2 for the three weapons. The lighter non-aluminized ballonett showed first effects between 3.9 and 6.3 cal/cm^2. Destruction of the surface and fabric for the N 113 A 100 material was not attained for the 39 KT weapon, since sufficient irradiance was not available; the maximum exposure possible for this $t_{(max)}$ time being 27 cal/cm^2. For the same reason, the N 113 A 70 material was not destroyed for $t_{(max)}$ = 0.20 sec. The two later stages of destruction for the N 113 A 100 material occurred at radiant exposures ranging from 43 to 47 cal/cm^2 for the 113 and 1550 KT weapons, respectively. Sample N 113 A 70 suffered destruction of the outer surface at radiant exposures ranging from 18 to 37 cal/cm^2 for all three weapon yields, and complete destruction at radiant exposures between 35 and 42 cal/cm^2 for the two larger weapon yields. The absorptances and critical radiant exposures of the materials are given in Table I.

13. The ballonett, N 128 A 170, destroyed at radiant exposures ranging from 9.2 to 19 cal/cm^2. Samples N 113 A 100 and N 113 A 70 were each exposed backed with N 128 A 170 in casual contact at dosages bracketing the critical exposure. The results were the same as for single layer N 113 A 100 and N 113 A 70.

14. Since these exposures were made, the pulsing mechanism has been revised to give a pulse-form more nearly conforming to the generalized field pulse. The characteristics of this pulse are described by the expression:

$$Q = 1.74\, H_{max}\, t_{max}$$

The results were found to differ from those in the table by no more than $\pm$ 10%.

15. Graphical presentation of the results for initial effects and destruction indicates that the values of critical radiant-exposure would closely satisfy a relationship of the form

$$Qc = kW^a,$$

where Qc is the critical radiant exposure for the effect, W the weapon yield in kilotons, and k and a are constants. The constants as determined from the data are given in Table 2. The largest error would be in the case of N 128 A 170 where the maximum error in the range from 39 to 1550 kilotons could be as much as 10 percent. The error in the case of destruction of N 113 A 100 might be somewhat higher, due to the lack of data at 39 kilotons, however the critical exposure is expected to be no less than 28 cal/cm^2 and no greater than 47 cal/cm^2.

APPROVED:

A. B. JONES, JR., CAPTAIN, USN
The Director

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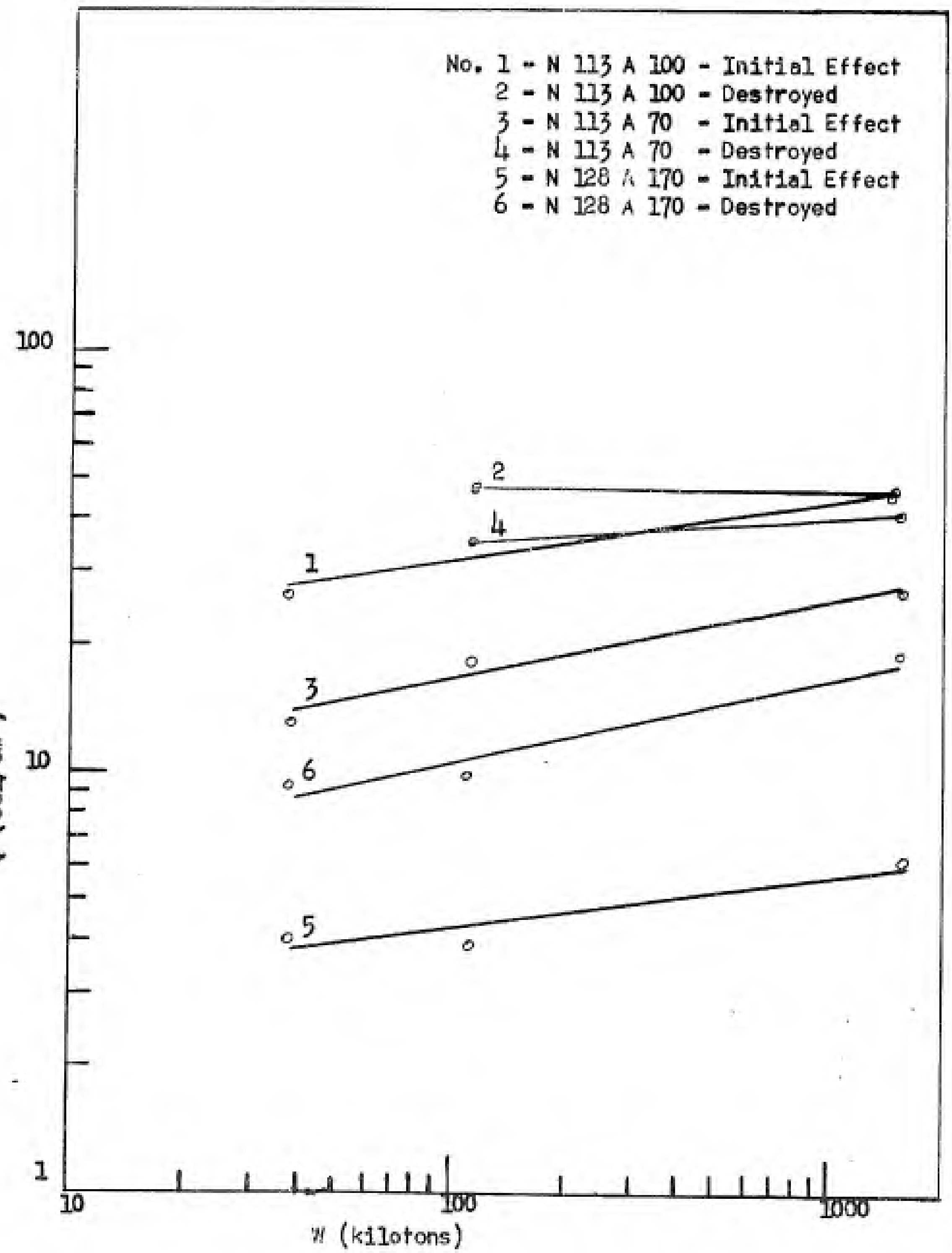

FIGURE 1 - Critical Radiant Exposure for Damage to Airship Fabrics as a Function of Weapon Yield.

TABLE I

Critical Radiant Exposures
on Airship Fabrics

Submitted by
Naval Air Station
Lakehurst, New Jersey

Fabric	Absorptance	Description of Effect	t_{max} (sec.)	Critical Exposure (cal/cm²)
Basketweave, 2 ply, 16.8 oz/yd², GAC No. N-113 A 100 (Airship Types ZSG-4 and ZPG-2).	0.352	Aluminized surface discolored.	0.20 0.40 1.26	26 35 44
		Aluminized surfacing destroyed.	0.20 0.40 1.26	>27 43 44-46
		Fabric destroyed, turns brittle and crumbles on flexing.	0.20 0.40 1.26	>27 47 47
Basketweave, 3 ply, 19.4 oz/yd², GAC No. - 113 A 70 (Airship Types ZSG-3).	0.407	Aluminized surface blisters, dulls.	0.20 0.40 1.26	13 18 27
		Aluminized surfacing destroyed.	0.20 0.40 1.26	18 27 37
		Fabric destroyed, turns brittle and crumbles on flexing.	0.20 0.40 1.26	>27 35 42
Cotton ballonett, 2 ply, 8.00 oz/yd², GAC No. - N 128 A 170 (Airship Types ZSG-3 & ZPG-2)	0.937	Delaminates, blister raised on front, back, or both surfaces.	0.20 0.40 1.26	4.0 3.9 6.3
		Fabric destroyed, turns brittle and crumbles on flexing.	0.20 0.40 1.26	9.2 9.7 19

TABIE 2

Values of k and a
for
Airship Fabrics

Submitted by
Naval Air Station
Lakehurst, New Jersey

Fabric GAC No.	Effect	k	a
N 113 A 100	Surface discolored	17	0.14
N 113 A 100	Fabric destroyed	47	0.0 (a)
N 113 A 70	Surface blisters	7.1	0.18
N 113 A 70	Fabric destroyed	26	0.07
N 128 A 170	Delaminates	2.1	0.18
N 128 A 170	Fabric destroyed	4.3	0.19

(a) Based on two points.

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CONFIDENTIAL

Three airship fabrics (submitted by the Naval Air Station, Lakehurst, New Jersey) were exposed to intense thermal radiation in the laboratory, simulating field pulses corresponding to weapon yields of approximately 40, 100, and 1500 KT. The critical radiant exposures of the material as measured for these energy releases were correlated with weapon yield.

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